General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

CR.72194

10-047-009 (REV. 6/63)

DIVISION SNAP-8

TM - 4923:65-4-309

DATE 16 July 1965

W.O. 0740-30-2210

TECHNICAL MEMORANDUM

AUTHOR(S): H. E. Bleil

TITLE: ALUMINUM-TO-COPPER KOLDWELDED JOINTS FOR SNAP-8 ELECTRICAL TERMINAL APPLICATIONS

ABSTRACT

Joints of ETP copper "Koldwelded" to 6061-T6 aluminum were evaluated by mechanical testing and metallographic examination after thermal exposure at 350°F for times up to 3000 hours. It was concluded that the joint is adequate for the intended use as SNAP-8 electrical terminal transition pieces where they will be exposed to a maximum temperature of 350°F for 10,000 hours.

APPROVED:

DEPARTMENT HEAD R. S. Carey

R. S. Carey

NOTE: This document is considered preliminary and is subject to revision as analysis progresses and additional data are acquired. The general reader may encounter internal reference not available to him.

I. INTRODUCTION

Joints are necessary in the SNAP-8 electrical system to provide a transition from aluminum to 304 stainless steel. To employ state-of-the-art techniques, the joint is fashioned by using a process termed "koldweld" to join aluminum to copper. Nickel is TIG welded to the copper and the stainless steel is TIG welded to the nickel to complete the transition. In the system, the joints will be required to withstand the 35G launching stress and a minor stress produced by a small pressure differential during the electrical power generating period. A maximum temperature exposure of 350°F for 10,000 hours will occur during the power generating period. In order to determine the effect of thermal exposure on the "koldwelded" joints, sample joints of electrolytic tough pitch (ETP) copper to 6061 T6 aluminum were exposed at 350°F for times up to 3000 hours after which the joints were evaluated by tensile testing.

II. PROCEDURE

Sample "koldwelded" joints of 6061 T6 to ETP copper with approximately 3/8 in. square cross sections were received from Utica Turbine Parts Division of the Kelsey Hayes Co. One specimen each was exposed at 350°F for each of three times 500 hours, 1500 hours, and 3000 hours. Subsequent to the exposure the specimens were machined into subsize round tensile specimens with two inch gage lengths and 21/64 inch gauge diameters. The specimens were tensile tested to determine mechanical strength and ductility as gauged by elongation and reduction in area. The specimens after testing are illustrated in Fig. 1.

III. RESULTS

The results of the post exposure tensile tests are listed in Table I. For comparison purposes, previously obtained tensile test results of as received joints and thermally cycled joints are included.[1] Only the two specimens which had been exposed at 350°F for 1500 and 3000 hours failed in the proximity of the koldwelded joint. Therefore, only those two specimens gave indications of the joint ductility. All other specimens failed in the copper on inch or more from the joint. As was anticipated, the elevated temperature exposure resulted in recrystallization of the copper in the cold worked area produced during joining. Fig. 2. After the 1500 and 3000 hour exposure periods, diffusion zones of 0.00008 and 0.00012 inches thickness respectively were present at the joint. Failure of these specimens occurred at the aluminum rich side of the diffusion zone. The ductility of the

joint as indicated by percent elongation (2%) and by reduction in area (14.4 and 14.84%) did not decrease between the 1500 and 3000 hour exposure times. A minor decrease in the tensile strength of the system was noted with increasing exposure time after 500 hours. This decrease could be due to normal variations between test specimens and testing techniques. It is presumed that the specimen failure area shifted from the parent metal copper to the aluminum side of the Cu-Al diffusion zone because of chemistry changes produced by the diffusion and overaging of the aluminum during the elevated temperature exposure. With increasing exposure time, the diffusion zone will continue to increase in width at a decreasing rate. The mode of failure at the joint has been established and it is anticipated that this mode will continue with exposures up to 10,000 hours. Typical data indicated that the mechanical properties of 6061 T6 will be subject to moderate changes due to 10,000 hour exposure at 350°F. Ref. 2 indicates the yield strength will remain unchanged, the ultimate strength will decrease by 7.8% and the elongation will increase by 20%.

CONCLUSIONS

(1) The mechanical properties of the koldwelded ETP copper to 6061 T6 aluminum joints are adequate to fulfill the system requirements for 10,000 hours.

(2) The weakest tensile strength area of the koldwelded ETP copper to 6061 T6 aluminum joint will shift from the parent metal copper to the aluminum side of a narrow diffusion zone produced by increasing exposure time at 350°F.

(3) The mode of tensile failure of the koldwelded ETP copper to 6061 T6 aluminum joints has been established after 1500 and 3000 hour exposures at 350°F. This mode will continue through 10,000 hour exposure with a moderate decrease in the tensile strength and an increase in the ductility probable.

REFERENCES

(1) Evaluation of Koldwelded Butt Joint Transition Piece, R. A. Mendelson, TM 390:64-4-183, 21 January 1964

(2) Aerospace Structural Metals Handbook, Vol. II, Dec. 1963, Air Force Materials Laboratory Research and Technology Div., Air Force Systems Command, Wright-Patterson Air Force Base

TABLE I

MECHANICAL PROPERTIES OF KOLDWELDED ETP COPPER TO 6061 T6 ALUMINUM JOINTS AFTER VARIOUS TIME EXPOSURES AT 350°F

Exposure Time at 350°F (Hrs)	.2% Yield Stress (ksi)	Ultimate Tensile Stress (ksi)	% Elongation in 1/2"	% Elongation in 1"	% Elongation in 2"	% Reduction in Area	Tensile Specimen Failure Location
0*	32.7	36.1	--	--	21	69.2	In copper 1-1/4" from joint
0*	33.6	35.5	--	--	21	71.6	"
500	33.7	38.2	0	0	14	--	In copper 1" from joint
1500	--	36.0	--	--	2	14.4	In joint
3000	29.8	35.1	8	4	2	14.8	In joint
10 cycles * between	29.5	34.9	--	--	24	72.0	In copper 1-1/4" from joint
70 and 500°F *	30.0	34.4	--	--	26	72.6	" "

* Results from Ref. (1)

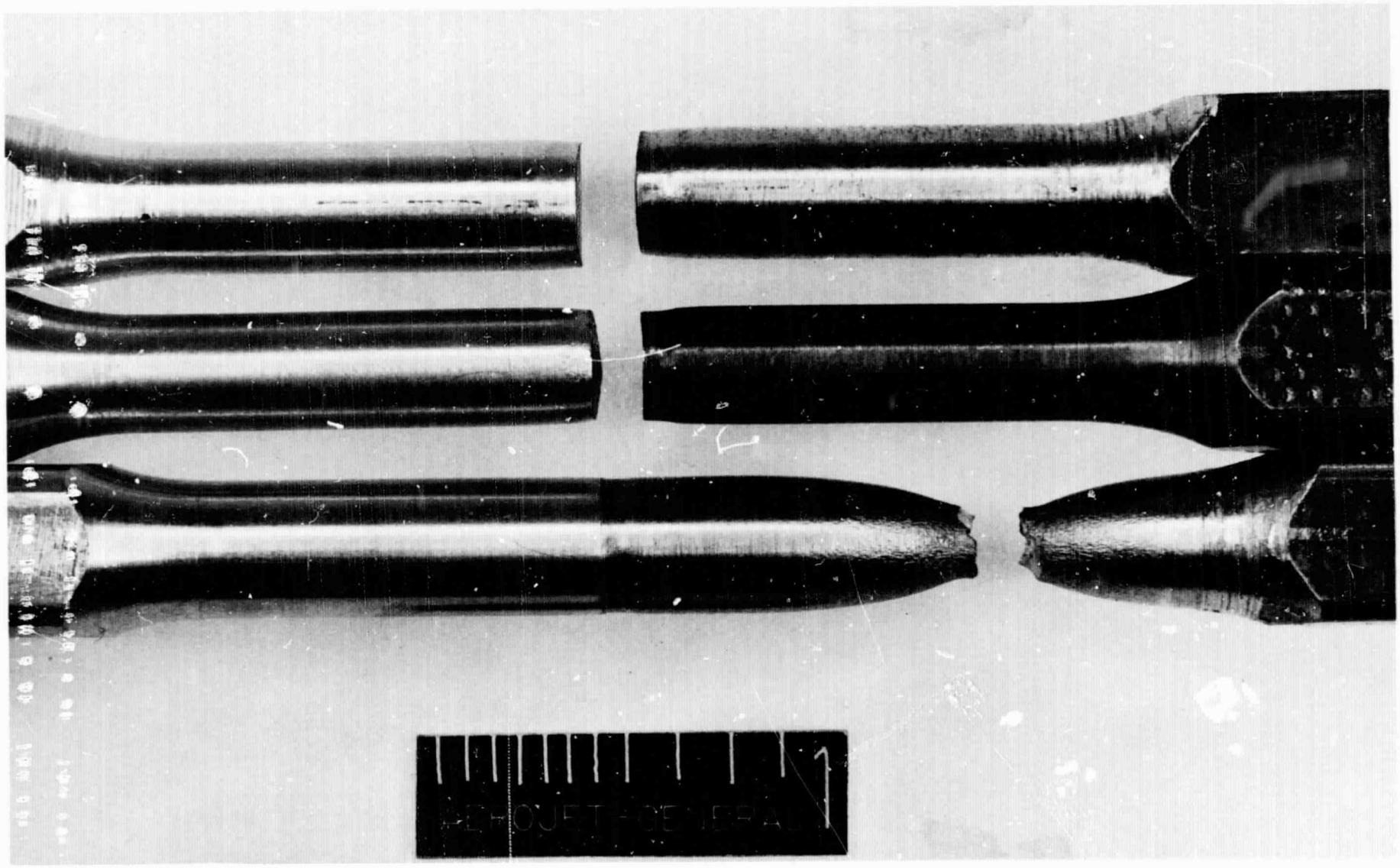
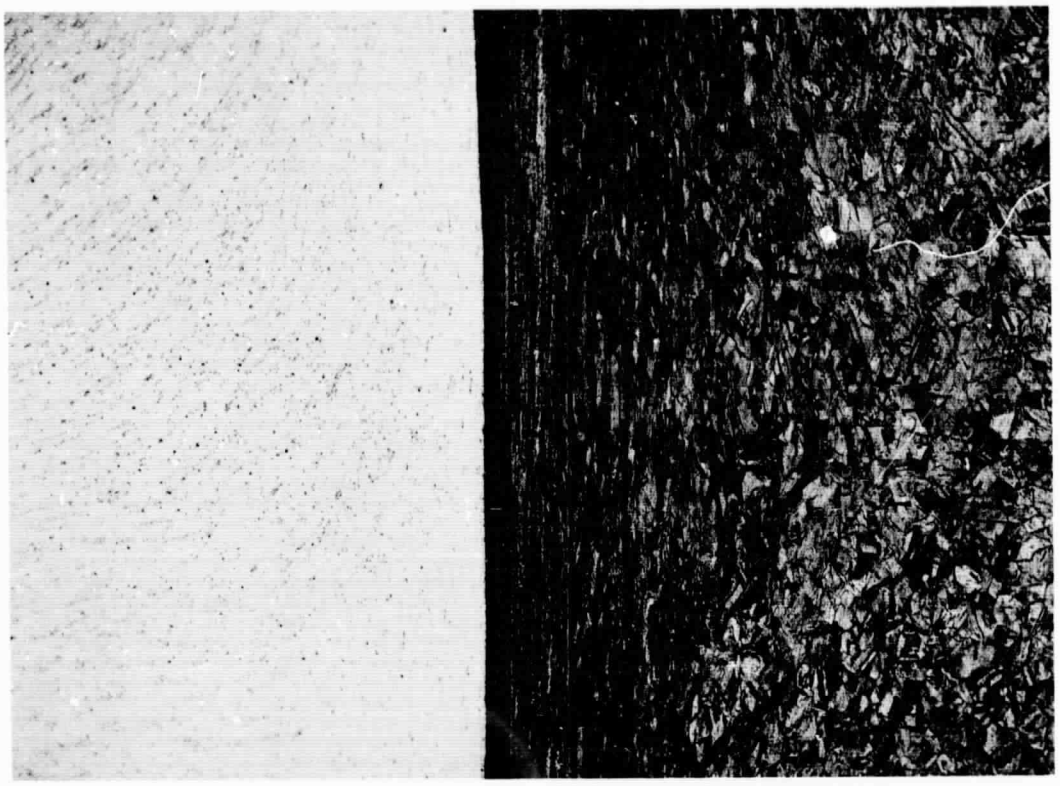
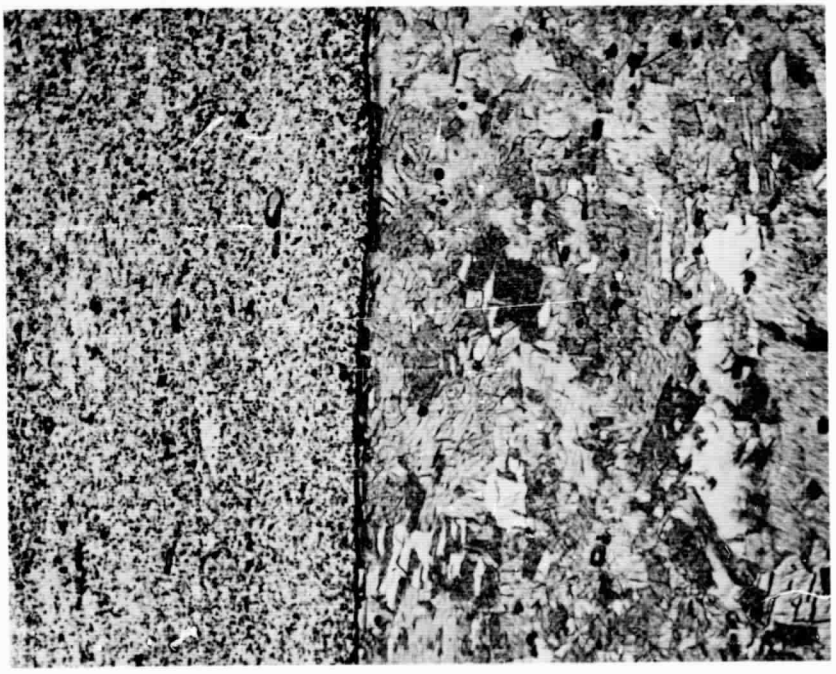


FIGURE 1

TENSILE SPECIMENS OF "KOLDWELDED" ETP COPPER TO 6061-T6 ALUMINUM AFTER EXPOSURE AT 350°F FOR 500, 1500 AND 3000 HRS.



A. As welded, copper at right, acetic acid - nitric acid etchant.



B. After 1500 hrs at 350°F, copper at right - Kellers and acetic acid - nitric acid etchant.

FIGURE 2

PHOTOMICROGRAPHS OF "KOLDWELDED" 6061-T6 ALUMINUM TO ETP COPPER JOINTS. 50X

APPENDIX I

CLEANING PROCEDURES UTILIZING AGC-10319/6 FLUIDS AND NaK

A. AGC-10319/6 Fluids -

Specimens were cleaned as follows:

1. Degrease in liquid trichloroethylene.
2. Immerse in MIL-C-14460, Type I fluid, which is at 190°F minimum, for 60-70 minutes.
3. Flush with tap water.
4. Immerse in a solution of Alconox (1 to 1½ oz/gal of tap water) which is at 85-110°F, for 15-20 minutes.
5. Flush with deionized water.
6. Dry by pressurized nitrogen.

B. NaK

The procedures for cleaning with NaK at both 1000°F and 1300°F were the same except for temperature. Cleaning was performed in a dry box and fresh NaK was used for each test.

A specially constructed "crucible" of 304 SS (approximately 1" I.D.) was wrapped with a Nichrome wire heating element and insulation and placed inside a Dewer flask (to prevent excess temperature rise in the dry box). Several specimens were placed together, staggering their positions to permit spacings between the specimens, and held together by wrapping a wire securely around the middle. The specimens were placed in the room temperature NaK and then heated to the desired temperature. (This took approximately 15-30 minutes.) After the specimens were at temperature for 1 hour, the hot NaK and specimens were dumped into a crucible.

After the specimens and NaK had returned to room temperature, they were cleaned by reacting with alcohol and water, and subsequently dried.